Brazilian Large and Long Programs (BrLLP)
Progress Report

The DIVING3D project: Deep IFS View of Nuclei of Galaxies

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Theses: Patricia da Silva[1], Inaiara Andrade[1] & Maiara S. Carvalho[2]

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1. Executive summary

The DIVING3D project - Deep IFS View of Nuclei of Galaxies – is one of the two Brazilian LLPs. By the end of 2016A it will be 63% completed. Additional time is requested to bring the degree of completion to 72%, when three sub-samples of the survey will be completed and statistical analysis of the ETG sample and the B<11.0 sample can be published.

The main goals of this survey are to perform a study of the a) nuclear and b) circumnuclear emission of a complete sample of all galaxies brighter than B=12.0 in the southern hemisphere. As a by-product we will also obtain stellar c) kinematics and d) archaeology.

So far we have published 6 papers on individual or small samples of galaxies. Two papers more have been submitted and three more are in preparation.

We found some interesting and even surprising results such as multiple AGN, multiple bulges and off-nuclear AGNs.

An advanced school on "3D Spectroscopy and Spectral Synthesis", the topic of the two Brazilian LLPs, was held in Campos do Jordão last November, with 70 attendants.

2. Work progress

The data quality is, in general, very good. Although all data cubes have instrumental fingerprints we have been able to remove them.
The signal-to-noise obtained for the emission line analysis is very good. For the stellar component of the central bulge it is quite appropriate. In two cases, at the edges of the FOV, we had deficit of s/n for analysing the stellar component, but this has not been a problem, given our objectives.
Only one object, NGC 4856, was not observed because of lack of guiding star. We will propose an observation with SOAR; either with SIFS or Goodman.
The wavelength calibration has been made very accurately. The flux calibration is not better then ~30%.
All data cubes are submitted to the following procedures:

- Calibration in wavelength
- Calibration in flux
- Correction for the differential atmospheric refraction (DAR).
- Fingerprint removal
- High frequency spatial noise removal with Butterworth filter
- Richardson-Lucy deconvolution

The data analysis is done with the following techniques:

- PCA Tomography
- Starlight spectral synthesis
- pPXF kinematic analysis, obtaining the Gauss-Hermite momenta

Software development

All software developed by our group in IDL is available in the site:

www.astro.iag.usp.br/~pcatomography

3. Recent results

A paper on the galaxy NGC 3621 has just been published in the Astrophysical Journal. In this paper we show that this previously known bulgeless galaxy with a Seyfert 2 nucleus has, in fact, an off-centered nucleus. The central stellar cluster has no emission lines and the Seyfert-like emission comes from about 2" from the stellar cluster. We propose and explore a few scenarios that could explain our observations, including the ejection of the black hole from the central cluster or a highly variable AGN.

One additional paper has been submitted to the MNRAS reporting the detection of a possible LBV/Hypergiant and Wolf-Rayet stars near the central cluster in the bulgeless galaxy NGC 1313.
The paper IV of the series on the 10 early type galaxies (ETGs) has been submitted and the referee report is being answered. This paper is about the stellar kinematics.

One of the main surprises of the data reduced so far is the frequency in which we find indications of past mergers:

a) At least in two cases we see double or well elongated central bulges. Associated to this there is strong indication of stellar population with 1 Gyear.
b) In two cases we see double AGN (~1" separation). In one case it is associated to a double central bulge.
c) In one case there is a suggestion of a triple AGN (within 0.7")
d) In two cases we see off-centered AGN. Perhaps this indicates the ejection of the central black hole, as a consequence of black hole merger.

The fact that this is an IFU survey with unprecedented resolution and signal-to-noise, such unprecedented findings are not surprising.

Considering the central source, we can make a preliminary statistics and compare it with the Palomar survey. The result shows that we are looking much deeper and finding significantly more AGNs.

Preliminary comparison with the Palomar Survey for massive ETGs (σ>200 km/s)

Type	Palomar Survey		DIVING3D	
	Nr	%	Nr	%
No Em.	19	33%	3	9%
L1.9	6	11%	10	31%
Lb?	0	0%	6	19%
S1.5	1	2%	2	6%
T1.9:	1	2%	0	0%
S2	0	0%	0	0%
S2:	1	2%		
L2	8	14%	4	13%
L2::	6	11%	7	22%
T2	2	4%		
T2:	7	12%		
H:	1	2%	0	0%

T2/L2-S2:	4	7%		
S2/L2	1	2%		
Total	57	100%	32	100%
No Em.	***19***	***33%***	***3***	***9%***
Lb/Sb	***8***	***14%***	***18***	***56%***
S2/L2/T2	***29***	***51%***	***11***	***34%***

Papers on individual objects that are in advanced phase of preparation:
NGC 1566
NGC 6744
NGC 613

We believe that a significant number of papers in individual objects will be published. The main goal, however is, at the end, publish statistical analysis on:

- The ETGs
- Early-type galaxies
- Milky Way Twins
- Late type galaxies

Our perspective is that in all cases we will address:

- Nuclear emission line properties
- Circumnuclear emission line properties
- Stellar archaeology
- Stellar kinematics

4. Overall status

The current membership of the project is:
Joao Steiner: Coordinator
Roberto Menezes: reduction, data processing and analysis. Emission line properties of the mini-DIVING3D.
Tiago Ricci: reduction and data processing and analysis. Priority on ETG galaxies.
Roberto Cid Fernandes, Natália do Vale e André Amorin: Spectral synthesis and stellar archaeology.
Paula Coelho: Spectral libraries; alfa enhancement.

Theses:
Patricia da Silva: the master thesis has just been submitted. She will start the PhD thesis, following the work on Sbc galaxies (Milky Way twins).
Inaiara Andrade: her PhD thesis focuses on IFU spectroscopy of nuclei of S0 galaxies.
Maiara S. Carvalho: her master thesis focuses on stellar archaeology of the mini-DIVING3D.

External collaboration: A paper is being prepared with Rogério Riffel, Rogemar Riffel and Gabriel Hahn in which the GMOS data of the galaxy NGC 1052 will be combined with their NIFS data.

5. Observing plan and data release

The current observing strategy is to observe sub-samples as listed below.

Observational strategy

Sub-samples

The observational status of the subsamples, by the end of semester 2016A will be:

Sub-sample	***Obs***	***Unobs***	***Total***
1 – High-mass (σ>200 km/s) ETGs	32	0	32
2 – Low-mass (σ<200 km/s) ETGs	23	7	30
3 – Early type (Sa-Sb) spiral galaxies	13	23	36
4 – Milky Way twins	18	5	23
5 – Late type (Sc-Sd) spiral galaxies	21	28	49
Total	***107***	***63***	***170***

The degree of completion, per subsample will be, by the end of the semesters 2016A and 2016B will be:

Priority	***Completion degree***	
	16A(17hs)	16B(17hs)
1 – High –mass ETGs	100%	100%
2 – Bright (B<11.0) Mini-DIVING^{3D}	93%	100%
3 – Low-mass ETGs	80%	100%
4 – Milky Way twins	74%	96%
5 – Early type spirals	36%	39%
6 – Late type spirals	43%	49%
Total	***63%***	***72%***

This means that, by the end of 2016B we will have a degree of completion of 100% for the sub-samples High-mas ETGs, Low-mass ETGs and Mini-DIVING 3D.

It is very important to notice that the two semesters B were not completed.
The program DIVING3D was approved in Nov/2013 and the time allocated by semester was:

Semester	time	observed#	not obsv
2014A	8.5hs	7	0
2014B	17hs	9	7
2015A	21hs	20	0
2015B	21.6	12	8
2016A	17hs		

In the semester 2014B, 7 galaxies were not observed due to an operational mistake by the Gemini Observatory. In 2015B 8 galaxies were not observed because of the bad weather due to the strong El Niño phenomenon.

For these reasons, semester A is well advanced (only 2017A is required in addition) while semesters B are late (semesters 2016B, 2017B and 2018B -10 hs - are still needed).

The proposed objects per semester are:

2016B - 17 hs
NGC 7793, NGC 1097, NGC 1232, NGC 1084, NGC 1617, NGC 1344, NGC 1326, NGC 1302, NGC 1201, NGC 596, NGC 1427, NGC 2207, NGC 1255, NGC 289, NGC 1515, NGC 1421

2017A – 20 hs
NGC 4593, NGC 3223, NGC 5170, NGC 5556, NGC 4818, NGC 4902, NGC 4941, NGC 4995
NGC 5334, IC 5273, NGC 6118, NGC 4504, NGC 6753, NGC 5584, NGC 5161, NGC 7496,
NGC 5530, NGC 3513

2017B - 17 hs
IC 5332, NGC 1448, NGC 1512, NGC 1350, NGC 7582, NGC 578, NGC 1042, NGC 1371,
NGC 1637, NGC 1532, NGC 7727, NGC 1087, NGC 1425, NGC 1964, NGC 210, NGC 1385

2018B – 11 hs
NGC 7713, NGC 1744, NGC 150, NGC 986, NGC 1249, NGC 1493, NGC 2090, NGC 7723
NGC 779, NGC 685

The Legacy strategy

Our commitment is to deliver the data to the Brazilian Astronomical Community. The idea is to give access to our community not only to the raw data (available after 1 year anyway) but also the reduced and the processed data. For this reason we will deliver two data cubes for each galaxy:

A – One data-cube with all spectra:
- Calibrated in wavelength
- Calibrated in flux
- Corrected for the differential atmospheric refraction (DAR).
- Fingerprint removed
- High frequency spatial noise removal with Butterworth filter

B – One additional cube will be available to the community with the additional data processing:
- Richardson-Lucy deconvolution

The data has been located in the projects' site ("DIVING3D" in CLOUD-USP). Due to budgetary restrictions, the University is not allowing any more such a use. The new site is being prepared in the VO server at IAG. In the meantime any data can be requested to
Tiago Ricci: tvricci@iag.usp.br or
Roberto Menezes: Roberto.menezes@iag.usp.br

We plan to deliver the next data releases one year after each of the subsample is completed. The next two releases will likely be in 2017B for the subsamples "Low-mass ETGs" and "Mini-DIVING3D" if they become completely observed in 2016B

6. Publications

Include all refereed papers published by the group containing results from the LLP data.

Menezes, R. B., Steiner, J. E., Ricci, T. V. 2013 Ap J 765, L40
Collimation and Scattering of the Active Galactic Nucleus Emission in the Sombrero Galaxy

Ricci, T. V., Steiner, J. E. & Menezes, R. B. 2014 MNRAS 440, 2429 – Paper I
Integral field unit spectroscopy of 10 early-type galactic nuclei - I. Principal component analysis Tomography and nuclear activity

Ricci, T. V., Steiner, J. E. & Menezes, R. B. 2014 MNRAS 440, 2442 – Paper II
IFU spectroscopy of 10 early-type galactic nuclei - II. Nuclear emission line properties

Menezes, R. B., Steiner, J. E. & Ricci, T. V. 2014 Ap J Lett 796, L13
An off-centered active galactic nucleus in NGC 3115

Ricci, T. V.; Steiner, J. E.; Menezes, R. B. 2015 MNRAS 451, 3728
IFU spectroscopy of 10 early-type galactic nuclei - III. Properties of the circumnuclear gas emission.

R. B. Menezes, J. E. Steiner and Patrícia da Silva 2016, Astrophysical Journal 817, 150
The off-centered Seyfert-like compact emission in the nuclear region of NGC 3621

The following papers were submitted for publication:

The emission-line regions in the nucleus of NGC 1313 probed with GMOS-IFU: Wolf-Rayet stars and a B[e]/LBV candidate
R. B. Menezes and J. E. Steiner submitted to MNRAS, 2016

IFU spectroscopy of 10 early-type galactic nuclei - IV. Properties of stellar kinematics.
Ricci, T. V., Steiner, J. E. & Menezes, R. B. submitted for publication to the MNRAS, 2016

- Include separately all papers published by the group, which are related to the LLP (at least in terms of IFU methodology) and that did not make use of the LLP data.

Steiner, J. E.; Menezes, R. B.; Ricci, T. V.; Oliveira, A. S. Mapping low- and high-density clouds in astrophysical nebulae by imaging forbidden line emission 2009 MNRAS.396, 788

Steiner, J. E.; Menezes, R. B.; Ricci, T. V.; Oliveira, A. S. PCA Tomography: how to extract information from data cubes 2009 MNRAS 39, 64

Oliveira, A. S.; Steiner, J. E.; Ricci, T. V.; Menezes, R. B.; Borges, B. W. Optical identification of the transient supersoft X-ray source RX J0527.8-6954, in the LMC 2010 A&A 517, L5

Ricci, T. V.; Steiner, J. E.; Menezes, R. B. NGC 7097: The Active Galactic Nucleus and its Mirror, Revealed by Principal Component Analysis Tomography 2011 ApJ 734 L10

Steiner, J. E.; Menezes, R. B.; Amorim, Daniel Identification of a high-velocity compact nebular filament 2.2 arcsec south of the Galactic Centre 2013 MNRAS 431, 2789

Menezes, R. B.; Steiner, J. E.; Ricci, T. V. Collimation and Scattering of the Active Galactic Nucleus Emission in the Sombrero Galaxy 2013 ApJ 765 L40

Menezes, R. B.; Steiner, J. E.; Ricci, T. V. Discovery of an Hα Emitting Disk around the Supermassive Black Hole of M31 2013 ApJ 762 L29

Menezes, R. B., Steiner, J. E. & Ricci, T. V. 2014, MNRAS 438, 2597
A treatment procedure for Gemini North/NIFS data cubes: application to NGC 4151

Ricci, T. V.; Steiner, J. E.; Giansante, L. 2015 A&A 576, 58
A hot bubble at the centre of M81

Menezes, R.B., da Silva, P., Ricci, T.V., Steiner, J. E. & May, D., 2015 MNRAS 450, 369
A treatment procedure for VLT/SINFONI data cubes: application to NGC 5643

Menezes, R. B. & Steiner, J. E. 2015 Astrophysical Journal 808, 27
The molecular H2 emission and the stellar kinematics of the nuclear region of the Sombrero Galaxy.

May, D., Steiner, J. E., Ricci, T.V., Menezes, R.B, & Andrade, I.S. 2016 MNRAS 457, 949
Digging process in NGC 6951: the molecular disc bumped by the jet

- **Include any public communication related to the LLP such as: conference talks, public outreach, presentations in workshops and/or schools, etc.**

The XVII Advanced School in Astrophysics

We have promoted the XVII Advanced School in Astrophysics in the areas of the two LP programs being conducted in Brazil: **3D Spectroscopy and Spectral Synthesis**. This was a major event that required a lot of attention and work from our group.

The lecture topics were:
Lecture I –Active and non-active galactic nuclei in the NIR (Adaptive optics) – Richard Davies
Lecture II - Science from SAURON and ATLAS3D – Michele Cappellari
Lecture III – Science from CALIFA – Sebastian Sanchez
Lecture IV - Spectral Models - Guy Worthey
Lecture V – Science with Fabry-Perot - Philippe Amram

In addition individual review talks (80+10 min) by Brazilians were presented:
Cid Fernandes: Spectral fitting techniques
Thaisa Storchi-Bergmann: Feeding and feedback in AGN

Invited talks (40+5 min):
Claudia Mendes de Oliveira: BTFI Fabry-Perot spectrograph & FP+SAM
Paula Coelho: Alfa enhancement in spectral libraries
Rogério Riffel: Spectral synthesis in the NIR
Rogemar Riffel: 3D spectroscopy in the optical and NIR
Roberto Menezes:Treatment procedures for optical and NIR data cubes
Tiago Ricci: Long Program: DIVING^{3D} - Deep IFS View of Nuclei of Galaxies (optical IFU)
Alberto Ardila: The coronal line region
Eduardo Telles: Extragalactic H II regions

Coordinator: João E. Steiner
The School was held at the Orotur Hotel in Campos do Jordão and had 70 attendants.

- **Include any thesis or dissertation work finished that are related to the LLP.**

Roberto Menezes (2012): Methodology development for the program
Tiago Ricci (2013): 10 early type galaxy studies, including some from the DIVING3D
Patrícia da Silva (April 2016): Analysis of 4 SBsc galaxies (Milky Way twins).

7. Response to NTAC questions

Include here the responses to the specific questions raised by the NTAC.

Recomendação 1-

Although the report provided sufficient details about the status of the program in terms of the observations, it would be helpful to provide in the next report also

1) preliminary science results,
   See section 3.

2) indications of the data quality achieved (did the achieved S/N match the expectations, and what are the

implications for future observations?)
See section 2.
(3) a concise overview of the subjects of the papers they expect based on this program.
See section 3.

Recomendação 2-

The program has not yet generated publications (for reasons that have been properly addressed in the report). However, with more than 50% of the observations taken, I think that the team has more than enough material to start with an introductory paper announcing the DIVING3D project to the community. This paper does not need to include a lot of detailed new results. It should be seen as the main survey paper that introduces the science case, the sample, the observations, and perhaps 1 or 2 preliminary results. It should be possible to write such a paper in a few months.
We agree with the recommendation. We are working on the paper announcing the program. There was some uncertainty until 29 December, 2015 when the Minister signed the Gemini agreement. Until then it was not clear that Brazil would remain in the consortium. This program could have been interrupted. Now it is time for the paper announcing the program.

Recomendation 3-

See item 5 above.

Recomendação 4-

Each report should provide updated ETC information for EACH target to be observed in the next semester.
See appendix B. We have two ITCs: one for ETGs and one for spirals.

8. Additional material (optional)

Appendix A - Status of each object/subsample

1 - The sub-sample of high-mass (σ>200 km/s) ETGs

Name	Sem./ Red.	Type NED	B mag	d Mpc		gr/clust	AddObs
Ellipticals							
NGC 1316	13B/R	E4	9.6	20	SAB0^0(s)	Forn A	SINFONI; ACS/WFPC2
NGC 1549	13B/R	E0-1	10.76	16		Dor gr	
NGC 1399	08B/T	cD	10.79	18		Forn cl	SINFONI; ACS/WFPC2
NGC 3923	13A/T	E4-5	10.91	21			ACS
NGC 1407	13B/R	E0	10.93	23		Erid cl	ACS
NGC 3585	13A/T	E6	10.93	18			ACS/WFPC2
IC 1459	08B/T	E3-4	10.96	27			WFPC2
NGC 1404	08B/T	E1	11.04	19		Forn cl	ACS/WFPC2
NGC 720	13B/T	E5	11.15	24			
NGC 1395	13B/R	E2	11.18	21			
NGC 584	13B/T	E4	11.2	20			WFPC2
NGC 7507	13B/T	E0	11.43	22			
NGC 3557	13A/T	E3	11.46	37			WFPC2
NGC 1052	13B/T	E4	11.53	19			NIFS; ACS/WFPC2
IC 4296	13A/T	E	11.58	51		Gr(30)	ACS/WFPC2
NGC 4696	13A/T	cDpec	11.59	38		Cen cl	ACS/WFPC2
NGC 3962	13A/T	E1	11.66	31			
NGC 5018	13A/T	E3?	11.71	38			WFPC2
NGC 2974	13A/T	E4	11.78	25			WFPC2
NGC 6868	13A/T	E2	11.83	32			
NGC 4105	13A/T	E3	11.88	28			
NGC 5044	13A/T	E0	11.92	35			WFPC2
NGC 3904	13A/T	E2-3?	11.95	25			
NGC 1700	13B/T	E4	11.96	41			WFPC2
S0s							
NGC 3115	13A/R	S0^-	9.98	10.2			ACS/WFPC2
NGC 1380	08B/T	SA0	11.1	19		Forn cl	ACS/WFPC2
NGC 1574	13B/T	SA0^-(s)?	11.19	19		Dor gr	WFPC2
NGC 2784	13A/T	SA0^0(s)?	11.21	8.5			WFPC2
NGC 1332	13B/T	S0^-?(s)	11.24	20		Erid cl	SINFONI; WFPC2
NGC 5101	13A/T	(R)SB0/a(rs)	11.58	27			
NGC 2217	13B/T	(R)SB0+(rs)	11.59	19			
NGC 7049	13A/T	SA0^0(s)	11.64	28			ACS

Note (second column) - Reduced by: R = Roberto Menezes; T = Tiago Ricci; P = Patrícia Silva; I = Inaiara Andrade.
N1316 is a giant E. NED lists it as SAB0ˆ0(s)
NGC 1332, an elliptical (E6) or S0? (Kormendy and Ho, 2013

2 - The sub-sample of low-mass (σ<200 km/s) ETGs

Name	Sem/ Red	Type NED	B mag	d Mpc	group/clust	
Ellipticals						
NGC 5128	15A/R	S0 pec	7.89	3.7	Cen A	SINFONI
NGC 4697	14A/R	E6	10.11	12.3		
11.00						
NGC 1344	16B	E5	11.28	18.7	Erid cl	
NGC 5061	15A	E0	11.35	25.6		
NGC 7144	15B	E0	11.79	25.5		
NGC 0596	16B	cD pec?	11.88	21.5		
NGC 1427	16B	cD	11.94	19.4	Erid cl	
IC 5328	16A	E4	11.95	34.7		
S0s						
NGC 1291	14B/I	(R)SB0/a(s)	9.42	8.6		
NGC 1553	14B/R	SA0^0(r)	10.42	15.1	Dor gr	
NGC 5102	15A/I	SA0^-	10.64	18.8		SINFONI?
NGC 4753	15A/	I0	10.85	16.9	Virgo cl	
11.00						
NGC 0936	15A/R	SB0^+(rs)	11.19	20.7		
NGC 4546	08A/T	SB0^-(s)?	11.3	18.1		WFPC2
NGC 1326	16B/I	(R)SB0^+(r)	11.34	17.0		
NGC 6684	15A /Iok	(R')SB0^0(s)	11.34	12.4		
NGC 1302	16B	(R)SB0/a(r)	11.38	20		
IC 5267	15Aok	SA0/a(s)	11.39	26.1		
NGC 4856	XXX	SB0/a(s)	11.4	21.1	(Não observável; 15A)	SOAR?
NGC 4958	15Aok	SB0(r)? e-o	11.48	18.5		
NGC 1543	15Bok	(R)SB0^0(s)	11.49	17.2	Dor gr	
NGC 1201	16B	SA0^0(r)?	11.56	20.4		
NGC 1537	15Bok	SAB0^- pec?	11.62	18.5		
NGC 1527	15Bok	SAB0^-(r)?	11.7	16.6		
NGC 1411	15Bok	SA0^-(r)?	11.7	15.5		
NGC 4691	15A	(R)SB0/a(s) p	11.7	22.5		
NGC 1533	15Bok	SB0^-	11.71	18.4	Dor gr	
NGC 4984	16A	(R)SAB0^+(rs)	11.71	21.3		
NGC 1387	15Bok	SAB0^-(s)	11.83	17.2	Erid cl	
NGC 1947	15Bok	S0^- pec	11.86	16.3		

D(median) = 18.7 Mpc
NGC 5128 (Cen A) is an elliptical with a merger in progress (Kormendy and Ho, 2013).

3 - The sub-sample of early spiral galaxies (Sa-Sb)

Name		Type NED	B(T) mag	d (Mpc) Mpc	MksT			
M 104	10B/R	SA(s)a e-on	9.28	10.4	-25.36		NIFS; ACS/WFPC2	
NGC 1068	/R	(R)SA(rs)b	9.55	13.5	-24.66		NIFS; SINFONI	
NGC 1097	16B/Thai	SB(s)b	10.16	20.0				
NGC 1365	14B/	SB(s)b	10.21	17.9		Forn cl		
NGC 4699	13A/T	SAB(rs)b	10.44	24.7				
NGC 1398	15B/ ok	(R')SB(r)a	10.6	21.0		Erid cl		
NGC 1433	15B/ ok	(R')SB(r)ab	10.68	10.0				
NGC 1808	15B/ ok	(R)SAB(s)a	10.7	11.5				
11.00								
NGC 1672	15B/ok	SB(s)b	11.03	14.5		Dor gr		
NGC 7213	15A/ok	SA(s)a?	11.18	22			15A	
NGC 7410	15A/ok	SB(s)a	11.3	20.1			15A	
NGC 1617	16B /	SB(s)a	11.37	13.4		Dor gr		
NGC 1512	17B /	SB(r)a	11.38	12.3				
NGC 1350	17B /	(R')SB(r)ab	11.4	20.9		Erid cl		
NGC 7552	16A/	(R')SB(s)ab	11.4	17.1				
NGC 7582	17B/T	(R')SB(s)ab	11.46	20.6				SINFONI?
NGC 1371	17B/	SAB(rs)a	11.5	23.2		Erid cl		
NGC 1532	17B/	SB(s)b pec e-on	11.53	17.0		Forn cl		
NGC 7606	16A/	SA(s)b	11.55	31.5				
NGC 7727	17B/	SAB(s)a pec	11.55	23.3				
NGC 1425	17B/	SA(s)b	11.6	21.3		Forn cl		
NGC 1964	17B/	SAB(s)b	11.6	21.4				
NGC 0210	17B/	SAB(s)b	11.65	21.0				
NGC 4593	17A/	(R)SB(rs)b	11.72	33.9				
NGC 5792	16A	SB(rs)b	11.72	24.4				
NGC 0150	18B /	SB(rs)b?	11.75	21.0				
NGC 7496	17A/	SB(s)b	11.78	15.0				
NGC 0986	18B/	SB(rs)ab	11.8	17.1				
NGC 7723	18B/	SB(r)b	11.85	27.4				
NGC 0779	18B/	SAB(r)b	11.86	17.7				
NGC 3223	17A	SA(s)b	11.88	33.4				
NGC 4818	17A/	SAB(rs)ab pec?	11.89	20.0				
NGC 4941	17A/	(R)SAB(r)ab?	11.9	18.2				
NGC 4995	17A/	SAB(rs)b	11.9	28.9				
NGC 4902	17A/	SB(r)b	11.9	39.2				
NGC 6753	17A/	(R)SA(r)b	11.93	42				

D (median) = 21 Mpc

4 - The sub-sample of Milky Way twins (Sbc)

Name	Sem Red	Type NED	B(T) mag	d Mpc	MksT	Gr/cl	
NGC 6744	14A/okP	SAB(r)bc	9.24	9.5			
NGC 1566	13B/okP	SAB(s)bc	10.21	12.2		Dor gr	WFPC2
NGC 613	14B/okP	SB(rs)bc	10.75	25.1			HST; SINFONI H, K
NGC 1792	14B/ok	SA(rs)bc	10.85	13.2			
NGC 134	15A/okP	SAB(s)bc	10.96	18.9			
11.00							
NGC 157	14B/	SAB(rs)bc	11.04	19.5			
NGC 4030	14A/ok	SA(s)bc	11.07	24.5			
NGC 5247	15A	SA(s)bc	11.1	22.2			
NGC 1300	13Bok/T	SB(rs)bc	11.1	18.0	-24.11	Erid cl	ACS/WFPC2; SINFONI H, K
NGC 2442	14Aok	SB(s)bc pec	11.16	17.1			
NGC 2207	15A	SAB(rs)bc pec	11.35	26.5			WFPC2
NGC 5054	15Aok	SA(s)bc	11.51	19.8			
NGC 4939	15A	SA(s)bc	11.56	39			
NGC 7205	16A	SA(s)bc	11.57	19.4			
NGC 1255	16B	SAB(rs)bc	11.6	21.5			
NGC 3887	16A	SB(r)bc	11.6	19.3			
NGC 7314	16A	SAB(rs)bc	11.65	18.5			
NGC 7083	16A	SA(s)bc	11.8	33.3			
NGC 0289	16B	SB(rs)bc	11.81	22.8			
NGC 4981	16A	SAB(r)bc	11.83	24.7			
NGC 1515	16B	SAB(s)bc	11.93	16.9			
NGC 1421	16B	SAB(rs)bc?	11.95	26.4			
NGC 5530	17A	SA(rs)bc	11.98	14.			

D (median) = 19.5 Mpc

5 - The sub-sample of late type galaxies (Sc-Sd)

Name	Sem Red	Type Ned	B(T) mag	d Mpc	Gr/cl	
NGC 253	13B/R	SAB(s)c	8.13	3.1		Phoenix; ACS/WFPC2
N5236/M83	14A/R	SAB(s)c	8.51	7.0		ACS/WFPC2
NGC 300	13B/R	SA(s)d	8.7	2.0		ACS/WFPC2
NGC 1313	12B/R	SB(s)d	9.37	3.9		
NGC 247	15Aok	SAB(s)d	9.51	3.6		NIFS(2008)
NGC 7793	16B	SA(s)d	9.65	4.2		
NGC 3621	14A/R	SA(s)d	10.03	6.8		GNIRS(Mason); ACS/WFPC2
NGC 2997	14B/ok	SAB(rs)c	10.32	10.8		ACS/WFPC2
NGC 1232	16B	SAB(rs)c	10.5	18.7	Erid cl	
NGC 5068	15A	SAB(rs)cd	10.53	6.1		WFPC2
NGC 908	14B/ok	SA(s)c	10.87	17.6		
NGC 5643	14A/R	SAB(rs)c	10.89	16.9		WFPC2
NGC 1187	14B/ok	SB(r)c	10.93	18.8		
NGC 2835	15Aok	SB(rs)c	10.95	10.8		
NGC 1559	13B/ok	SB(s)cd	10.97	15.7		WFPC2
NGC 7424	13A/R	SAB(rs)cd	10.99	11.5		WFPC2
11.00						
NGC 7090	15B	SBc? e-on	11.1	8.4		ACS/WFPC2
NGC 1084	16B	SA(s)c	11.25	21.2		
IC 5332	17B	SA(s)d	11.25	8.4		WFPC2
NGC 1448	17B	SAcd? e-on	11.3	17.4		ACS
NGC 578	17A	SAB(rs)c	11.48	21.8		
NGC 1042	17B	SAB(rs)cd	11.49	9.4		WFPC2
NGC 1637	17B	SAB(rs)c	11.52	10.7		
IC 5201	15Aok	SB(rs)cd	11.54	14.4		
NGC 4731	15A	SB(s)cd	11.55	19.7		
NGC 3511	15A	SA(s)c	11.56	14.3		
NGC 1087	17B	SAB(rs)c	11.56	17.5		
NGC 4666	15A	SABc?	11.56	18.2		
NGC 7713	18B	SB(r)d?	11.65	10.3		
NGC 1385	17B	SB(s)cd	11.65	14.9	Erid cl	
NGC 3672	16A	SA(s)c	11.66	27.1		
NGC 4487	16A	SAB(rs)cd	11.66	20.0		
NGC 7184	16A	SB(r)c	11.67	33.6		
NGC 4781	16A	SB(rs)d	11.69	16.1		
NGC 1744	18B	SB(s)d	11.7	10.8		
NGC 4775	16A	SA(s)d	11.74	26.6		
NGC 1249	18B	SB(s)cd	11.8	15.8		
NGC 1493	18B	SB(r)cd	11.82	11.3		
NGC 2090	18B	SA(rs)c	11.85	12.8		
NGC 5170	17A	SA(s)c? e-on	11.88	27.3		
NGC 5556	17A	SAB(rs)d	11.88	18.7		
NGC 5334	17A	SB(rs)c?	11.9	32.6		
IC 5273	17A	SB(rs)cd?	11.9	16.6		
NGC 6118	17A	SA(s)cd	11.91	23.4		
NGC 4504	17A	SA(s)cd	11.92	21.8		
NGC 5584	17A	SAB(rs)cd	11.95	26.7		
NGC 685	18B	SAB(r)c	11.97	15.2		
NGC 5161	17A	SA(s)c?	11.98	24.3		
NGC 3513	17A	SB(rs)c	11.99	13.1		

D(median) = 15.7 Mpc

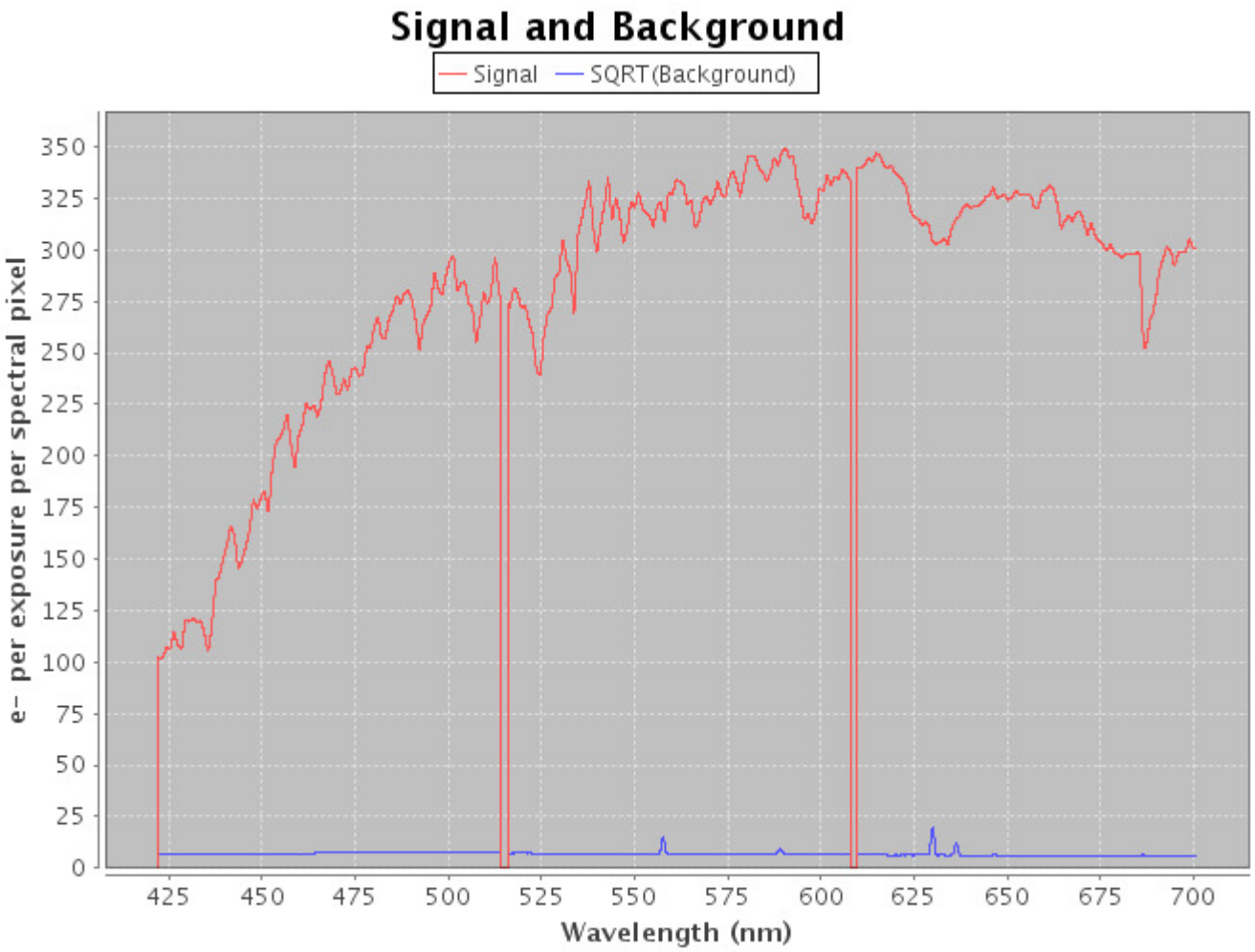
Appendix B - Output from ITC for the early-type and late-type galaxies of the sample

Gemini Integration Time Calculator
GMOS version 5.0

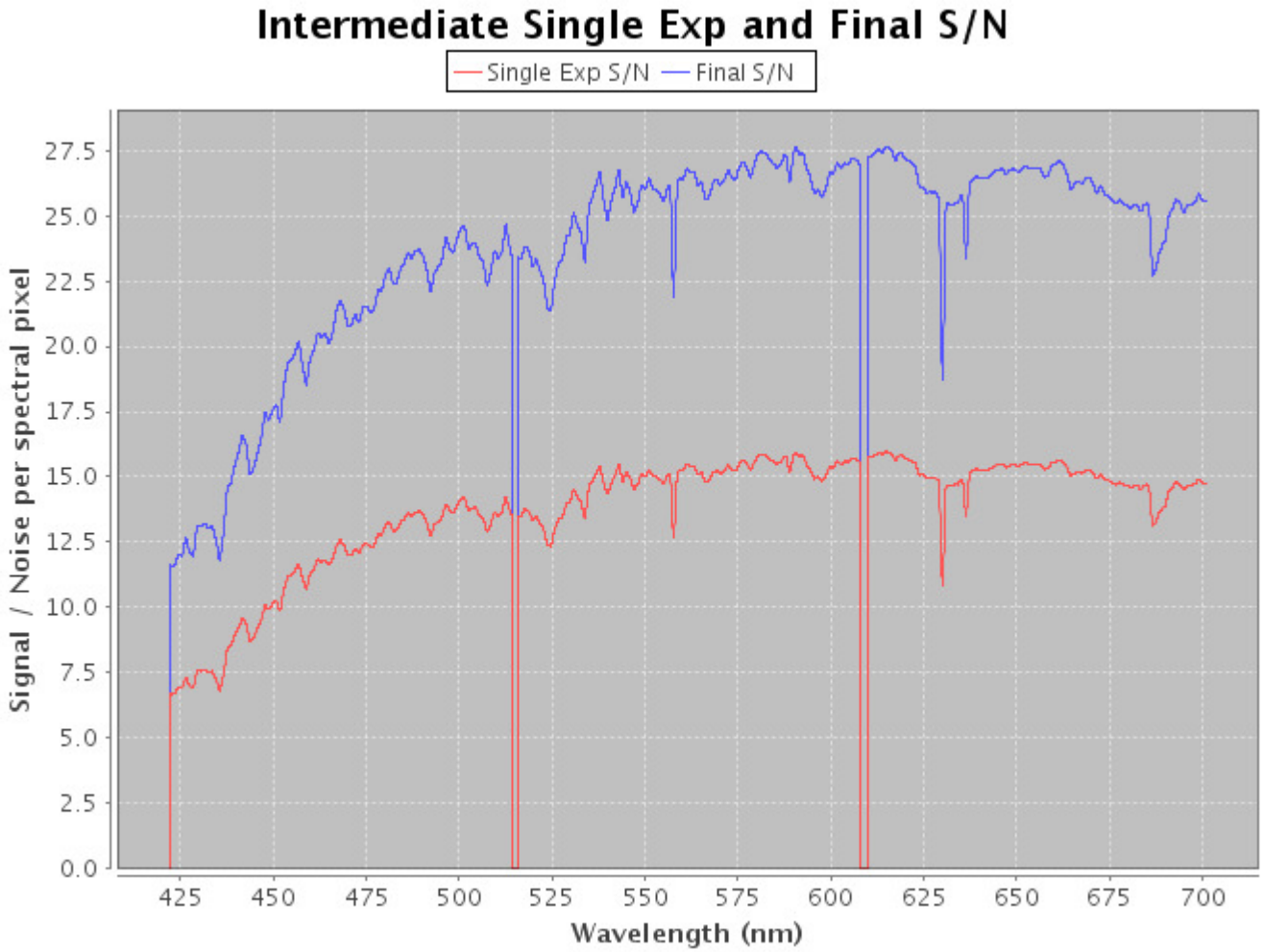
Click here for help with the results page.
Read noise: 4.1
derived image size(FWHM) for a point source = 0.88arcsec

Sky subtraction aperture = 500.0 times the software aperture.

Requested total integration time = 1800.00 secs, of which 1800.00 secs is on source.



Click here for ASCII signal spectrum.
Click here for ASCII background spectrum.



Click here for Single Exposure S/N ASCII data.
Click here for Final S/N ASCII data.

Input Parameters:
Instrument: GMOS-S

Source spatial profile, brightness, and spectral distribution:
The extended source is a 16.71 mag_per_sq_arcsec elliptical-galaxy at B.

Instrument configuration:
Optical Components:
- Fixed Optics
- IFU Transmission
- Grating Optics: B600_G5303
- Detector - GMOS South CCDs
- Focal Plane Mask: ifu

Central Wavelength: 562.0 nm
Spatial Binning: 1
Spectral Binning: 1
Pixel Size in Spatial Direction: 0.072arcsec
Pixel Size in Spectral Direction: 0.045nm

IFU is selected,with a single IFU element at 0.0arcsecs.

Telescope configuration:
- silver mirror coating.
- side looking port.
- wavefront sensor: oiwfs

Observing Conditions:
- Image Quality: 70.00%
- Sky Transparency (cloud cover): 70.00%
- Sky transparency (water vapour): 100.00%
- Sky background: 80.00%
- Airmass: 1.20

Frequency of occurrence of these conditions: 39.19%

Calculation and analysis methods:
- mode: spectroscopy
- Calculation of S/N ratio with 3 exposures of 600.00 secs, and 100.00 % of them were on source.
- Analysis performed for aperture that gives 'optimum' S/N and a sky aperture that is 500.00 times the target aperture.

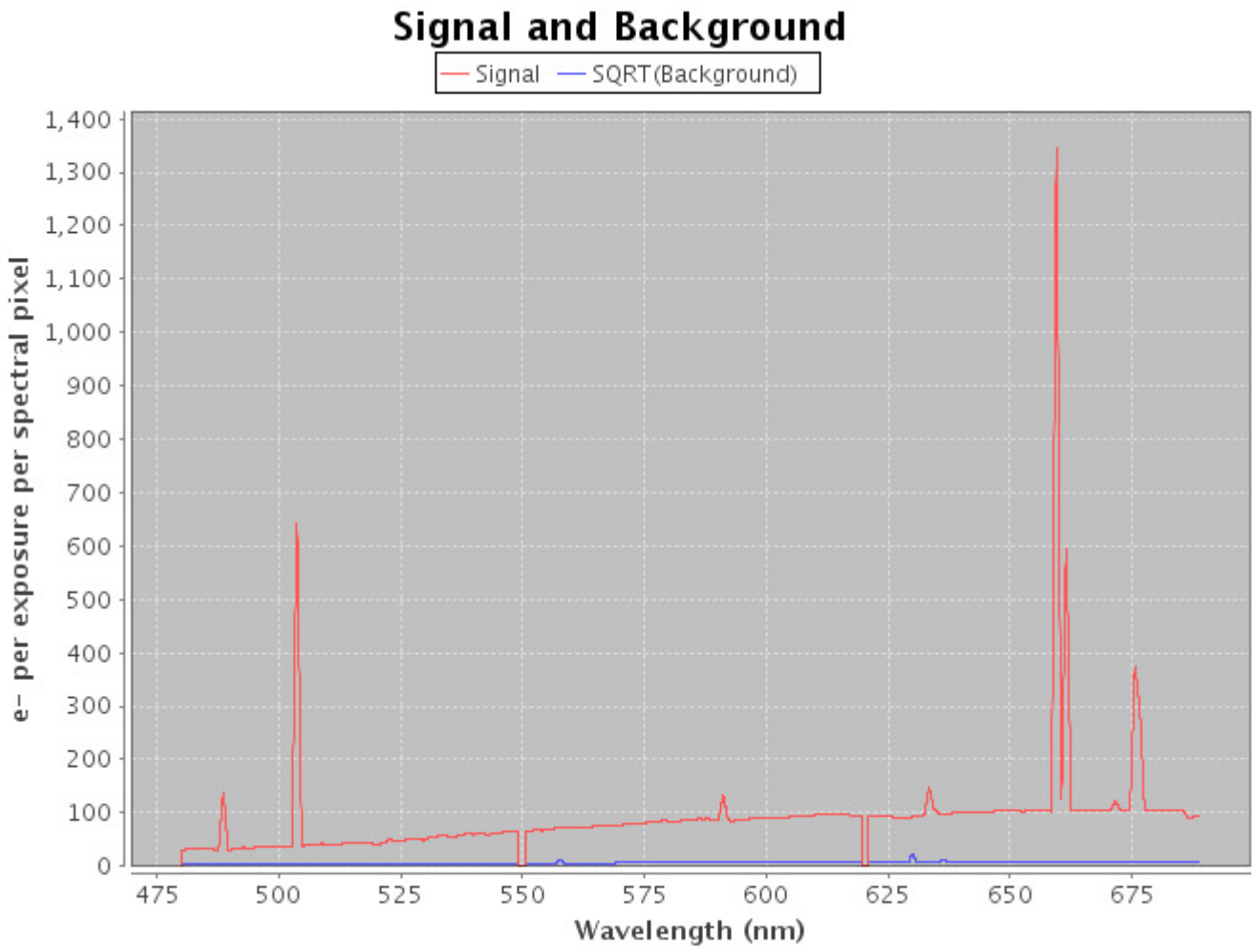
Output:
- Spectra autoscaled.

Gemini Integration Time Calculator
GMOS version 5.0

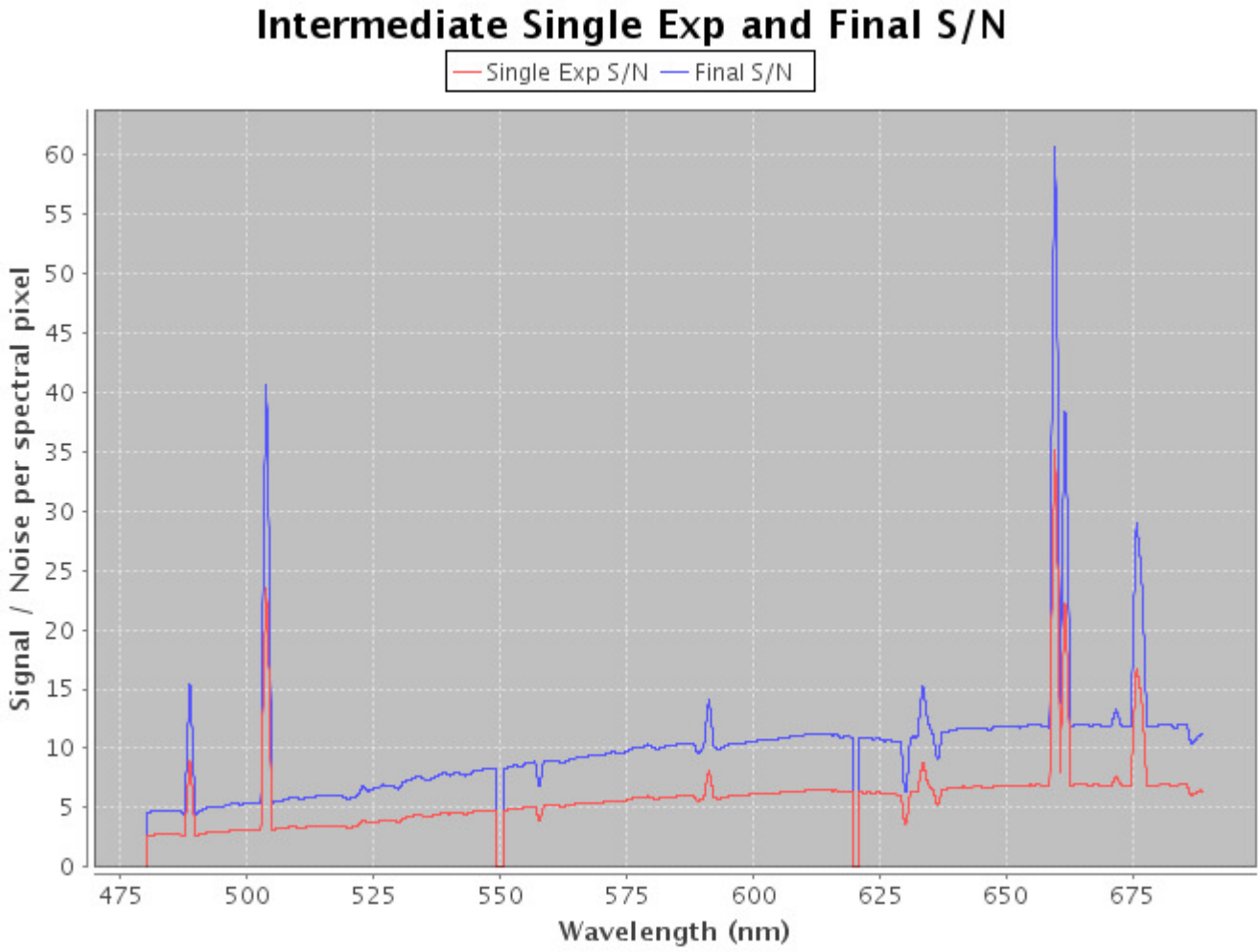
Click here for help with the results page.
Read noise: 4.1
derived image size(FWHM) for a point source = 0.88arcsec

Sky subtraction aperture = 500.0 times the software aperture.

Requested total integration time = 2700.00 secs, of which 2700.00 secs is on source.



Click here for ASCII signal spectrum.
Click here for ASCII background spectrum.



Click here for Single Exposure S/N ASCII data.
Click here for Final S/N ASCII data.

Input Parameters:
Instrument: GMOS-S

Source spatial profile, brightness, and spectral distribution:
The extended source is a 17.67 mag_per_sq_arcsec spiral-galaxy at B.

Instrument configuration:
Optical Components:
- Fixed Optics
- IFU Transmission
- Grating Optics: R831_G5302
- Detector - GMOS South CCDs
- Focal Plane Mask: ifu

Central Wavelength: 585.0 nm
Spatial Binning: 1
Spectral Binning: 1
Pixel Size in Spatial Direction: 0.072arcsec
Pixel Size in Spectral Direction: 0.0337nm

IFU is selected,with a single IFU element at 0.0arcsecs.

Telescope configuration:
- silver mirror coating.
- side looking port.
- wavefront sensor: oiwfs

Observing Conditions:
- Image Quality: 70.00%
- Sky Transparency (cloud cover): 70.00%
- Sky transparency (water vapour): 100.00%
- Sky background: 80.00%
- Airmass: 1.20

Frequency of occurrence of these conditions: 39.19%

Calculation and analysis methods:
- mode: spectroscopy
- Calculation of S/N ratio with 3 exposures of 900.00 secs, and 100.00 % of them were on source.
- Analysis performed for aperture that gives 'optimum' S/N and a sky aperture that is 500.00 times the target aperture.

Output:
- Spectra autoscaled.